# Decentralized Cooperative Navigation for Small Unmanned Aerial Vehicles in GPS-denied Environments, Phase I

Completed Technology Project (2018 - 2019)

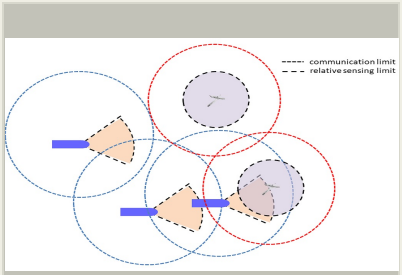
## Project Introduction

The use of small unmanned aerial vehicles (SUAVs) for civilian as well has military tasks, has been expanding steadily over the years. In this regard, cooperation and interoperability amongst multiple SUAVs has been seen as a key direction of future research by National Aeronautics and Space Administration (NASA). A central challenge in the cooperative navigation using multiple SUAVs is that they often have to operate in GPS-denied environment due to GPS jamming and spoofing or due to the unavailability of any external sources such as georeferencing, for navigation updates for long periods of time. An approach to address this problem is to employ cooperative navigation algorithms by which multiple SUAVs derive better estimates of their location using ownship navigation sensors, in conjunction with navigation data derived from other SUAVs in the vicinity. This proposal advances the development of decentralized cooperative navigation (DCN) algorithms that can improve the navigation performance of multiple SUAVs in GPS-denied environments. The proposed algorithm will tackle the challenges such as communication range and bandwidth limits, relative measurement sensor range and field of view limit, heterogeneous sensor systems and scalability with respect to the number of SUAVs. The Phase I work will provide proof-of-concept for the proposed DCN methodology using simulations. In Phase II, a working prototype will be developed and will be tested using hardware-in-the-loop simulations. The outcome of the research would be a technology for multivehicle cooperative navigation in GPS-denied and GPS-weakened environments.

## Anticipated Benefits

The proposed technology has direct relevance to the strategic thrust 6: Assured Autonomy for Aviation Transformation. It will support the ADS-B for Traffic Situational Awareness program. The developed method will help in controlling several UAVs simultaneously in GPS denied regions. The Automated Cooperative Trajectories (ACT) program will benefit from the proposed technology as the intent of each vehicle can be predicted and thus wake vortex behavior can be forecast.

There are several civilian applications such as cargo delivery and Urban Air Mobility (UAM) which requires navigating through tall buildings where GPS signal is weakened. The proposed method can be used for forest fire monitoring pose where the SUAVs has to navigate through large trees to find traces of forest fire hazards. Military applications include use in autonomous guidance of weapons and missile sin GPS-denied regions. Other applications include disaster response and agricultural support.

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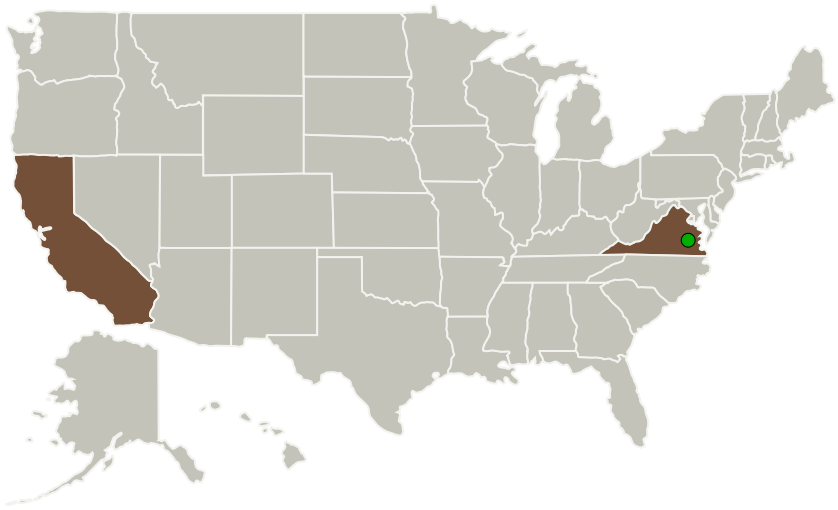
## Primary U.S. Work Locations and Key Partners



| Organizations Performing Work | Role | Type | Location |
|---|---|---|---|
| Optimal Synthesis, Inc. | Lead Organization | Industry<br>Small Disadvantaged Business (SDB) | Los Altos, California |
| Langley Research Center(LaRC) | Supporting Organization | NASA Center | Hampton, Virginia |

| Primary U.S. Work Locations | |
|---|---|
| California | Virginia |

## Project Transitions

**July 2018:** Project Start

**February 2019:** Closed out

**Closeout Documentation:**

- Final Summary Chart*(https://techport.nasa.gov/file/141322)*

## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Lead Organization:**

Optimal Synthesis, Inc.

**Responsible Program:**

Small Business Innovation Research/Small Business Tech Transfer

## Project Management

**Program Director:**

Jason L Kessler

**Program Manager:**

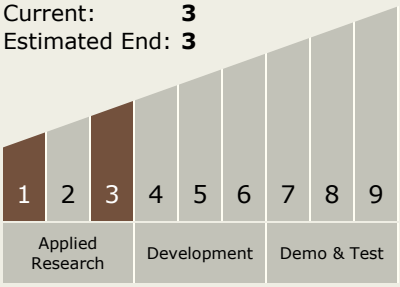
Carlos Torrez

**Principal Investigator:**

Bong-jun Yang

## Technology Maturity (TRL)

Start: **1**
Current: **3**
Estimated End: **3**



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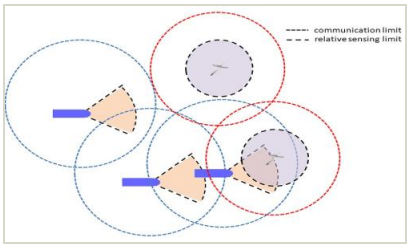
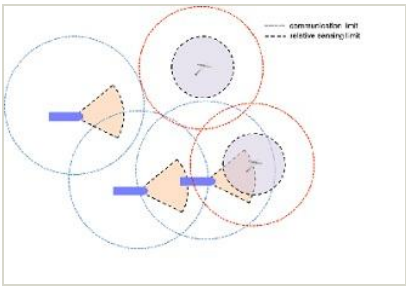
## Images




**Briefing Chart Image**
Decentralized Cooperative Navigation for Small Unmanned Aerial Vehicles in GPS-denied Environments, Phase I
*(https://techport.nasa.gov/image/134726)*



**Final Summary Chart Image**
Decentralized Cooperative Navigation for Small Unmanned Aerial Vehicles in GPS-denied Environments, Phase I
*(https://techport.nasa.gov/image/135136)*

## Technology Areas

**Primary:**

- TX01 Propulsion Systems
  - TX01.3 Aero Propulsion
    - TX01.3.1 Integrated Systems and Ancillary Technologies

## Target Destination

Earth